

National Bureau of Standards



December 1955
Volume 39
Number 12

Technical News Bulletin

DEC 14 1955
DETROIT

A Cardiographic Jerkmeter

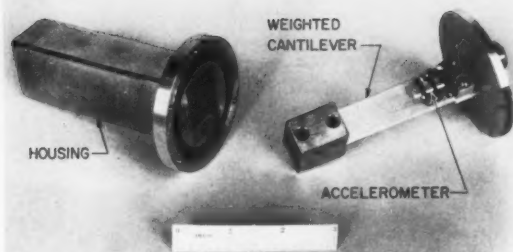
THE National Bureau of Standards has devised a barium titanate jerkmeter for studying the action of the human heart. The instrument is essentially a piezoelectric accelerometer with an output that is electrically differentiated. Unlike most instruments used in ballistocardiography, the jerkmeter does not require a fixed reference point. Thus, it is inherently isolated from extraneous motions, such as building or operating-table vibrations. The device was designed and constructed by T. A. Perls and C. W. Kissinger under a program of basic instrumentation sponsored at the Bureau by the Department of Defense and the Atomic Energy Commission.

In general, a jerkmeter is a transducer which gives an electrical output proportional to jerk, the time derivative of acceleration. Jerk has been measured in connection with elevator and vehicle riding comfort as well as in various physiological studies.¹ The present development was undertaken to obtain measurements of the third time-derivative of the displacement of a reclining patient. The motion of interest is due to the inertial forces generated by the flow of blood and is therefore intimately related to the function (and malfunctions) of the heart. Developed as a research tool, the jerkmeter is being used by the Civil Aeronautics Administration to study the correlation of jerk measurements with proper diagnosis of heart conditions.

Previous studies² have shown that the important frequencies for ballistocardiography extend from zero to about 20 cps. Certain muscular tremors of higher frequency, apparently unrelated to heart action, make it necessary for jerkmeter-frequency response to drop off as rapidly as possible above 20 cps. In the present device, very fast drop-off is achieved by taking advantage of the mechanical resonance of the accelerometer and by properly selecting the time constant (RC) of the differentiator.

The jerkmeter makes use of a loaded cantilever to obtain the required low fundamental resonant frequency. In the present design the second mode of resonant oscillation is 11 times that of the fundamental. Thus the second mode does not interfere with the frequency-response drop-off in a range where normal recording equipment would have appreciable sensitivity.

Electrical signals are obtained from a small barium-titanate sandwich-type element. The element is attached near the clamped end of the cantilever by means of three metal straps. In order to minimize the effect of the temperature sensitivity of the element and to provide an adjustable viscous damping, the cantilever is enclosed in a container filled with a silicone fluid. The fluid was chosen on the basis of tests and theoretical considerations which determined the viscosity neces-



sary for satisfactory damping. Temperature-dependency tests indicate that the jerkmeter sensitivity remains within 10 percent of its zero-frequency value up to 17.5 cps provided the temperature remains between 18° and 24° C.

The jerkmeter was calibrated under quasi-steady-state conditions by comparison with a commercial accelerometer previously calibrated by the "chatter" method.³ Response to this accelerometer was made independent of frequency within 2 percent, down to 1 cps, by means of a capacitive shunt and cathode follower. The two transducers were mounted back-to-back on the end of a long cantilever bar. The other end of the bar was clamped in a vise. By changing the free

Jerkmeter developed for use in ballistocardiography. A barium-titanate piezoelectric element is mounted on the right end of the cantilever by means of three phosphor-bronze straps. When the cantilever is disturbed by forces generated by the patient's blood flow, strains are developed in the element causing it to produce an electrical signal. Housing normally contains a silicone damping fluid.

length of the bar, and by changing bars, a test-frequency range from 1 to 60 cps was covered.

Over its "flat" frequency range the jerkmeter's sensitivity (voltage output per unit jerk) is the product of the accelerometer charge sensitivity and the load resistance. The low-frequency jerk sensitivity is thus independent of the capacitance of the circuit. This is an advantage since the input capacitances of amplifiers suitable for jerkmeter use are not always readily measured.

For use in ballistocardiography, the jerkmeter is attached to the subject's body by coupling means of known characteristics. It may, for example, be mounted on a wooden platform which rests on the shins of a reclining patient. For good mechanical contact, the shins may be wrapped with short sections of elastic bandage.

¹ See, for example, D. P. Eckman, *Industrial instrumentation*, p. 213 (John Wiley & Sons, New York, N. Y., 1950).

² J. E. Smith, M. D. and R. Rosenbaum, *Am. Heart J.* 46, 799 (1953).

³ C. W. Kissinger, *Instr. Soc. of Am., Paper No. 54-40-1* (September 1954, reprinted March 1955).

Creep of High-Purity Nickel

ALL METALS CREEP—that is, deform continuously—provided temperature and stress are sufficiently high. Although this phenomenon is often observed, no universally acceptable physical theory has yet been developed for the mechanism of plastic flow in creep. The interrelation of strain hardening, recovery, and recrystallization in the process are not fully understood, and there is a need for precise data on the creep of metals and alloys under carefully controlled conditions.

As part of a long-range research program in this field, the Bureau recently completed a study of the creep characteristics of high-purity nickel.¹ The work was carried out by W. D. Jenkins, T. G. Digges, and C. R. Johnson of the thermal metallurgy laboratory. Previous phases² of the program have dealt with the creep of high-purity copper, high-purity aluminum, and ingot iron. The results on nickel should be of particular interest because of the relatively low temperature at which creep occurs in this metal and the current wide use of nickel alloys in jet engines, electric heating elements, and other high-temperature applications.

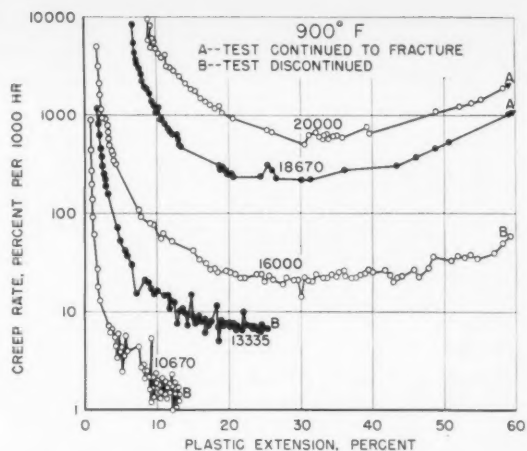
The investigation dealt with the creep behavior in tension of annealed specimens of high-purity nickel under constant load at 300°, 700°, 900°, and 1,200° F. The influence of rate of loading on creep behavior and

the effect of strain history on the tensile properties of the nickel at room temperature were also evaluated. In addition, contour and hardness surveys were made both on specimens fractured in creep and on specimens fractured in tension at room temperature. The creep and tensile behavior of the specimens was correlated with their microstructures.

The specimens were rods of 2-in. gage lengths and 0.505-in. diameters processed from an ingot that was prepared by induction melting. In the creep studies the specimens were heated in air to the desired temperature and held at this temperature for 48 hours. Increments of load were then added at intervals until the desired creep stress was reached.

In general, creep takes place in three stages, which follow the initial extension that occurs on application of the load. The first stage is one of decreasing rate of extension. Then, in the second stage, creep proceeds at a nearly constant rate. The third stage is one of increasing rate, culminating in complete fracture.

Discontinuous flow was observed in each of the three stages of creep at the temperatures investigated. The discontinuities were manifested as serrations in curves of extension versus time and creep rate. The magnitude and frequency of these serrations were affected by such factors as temperature, stress, strain aging, strain



Semilogarithmic curves of creep rate versus extension for high-purity nickel at various temperatures. Serrations in the curves indicate discontinuous flow in creep.

cially prominent at 300° F, as was manifested by an appreciable creep life in some specimens loaded relatively slowly to stresses in excess of the tensile strength (46,400 lb/in.²) at this temperature.

The experimental values for primary creep agreed fairly closely with the results predicted by the theory of exhaustion and generation of dislocations as proposed by Mott and Nabarro and modified by others. However, the creep rate in the secondary and tertiary stages could not be predicted accurately by existing formulas.

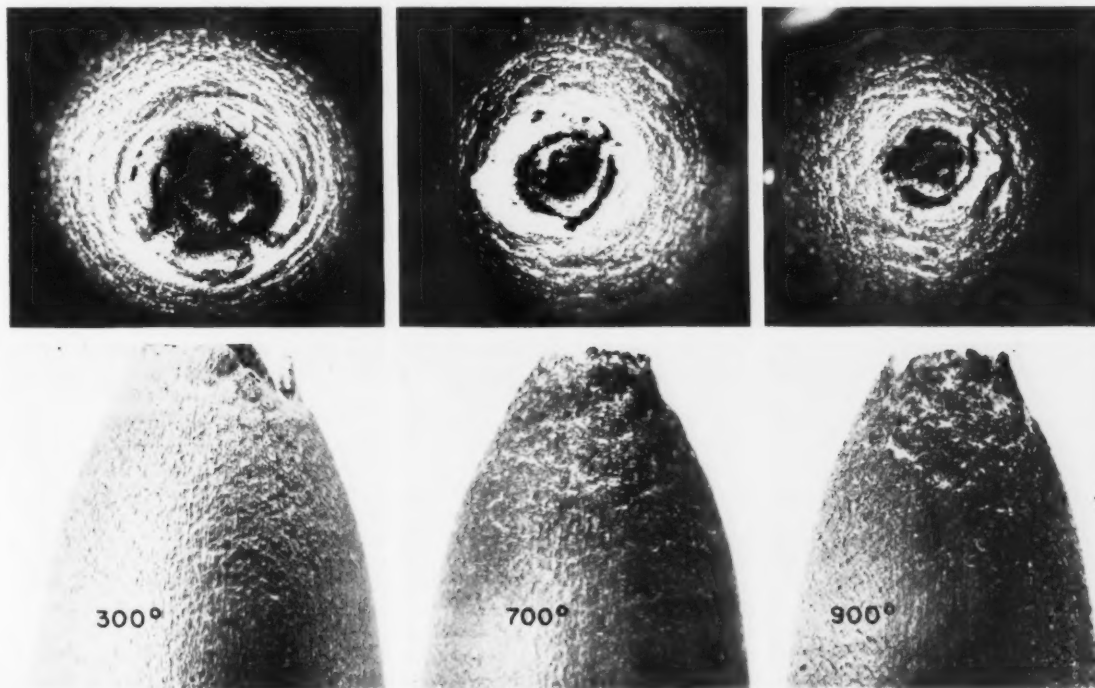
Logarithmic plots of creep rate versus time were nearly linear in the initial portion of the first stage of creep. However, nonlinear relations were generally obtained between stress and secondary creep rate when experimental values were plotted on either a log-log or semilog (log of rate) basis. Moreover, the secondary rate was not a consistent index to the ductility of the nickel at the beginning of the tertiary stage or at fracture.

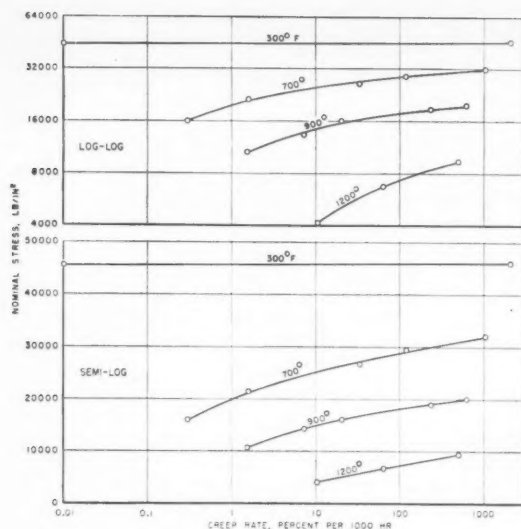
The prior strain history of the nickel had a marked effect on the secondary creep rate. The Bureau's experimental results thus emphasize the importance of controlling the rate of loading in creep testing.

hardening, recovery, recrystallization, grain orientation, grain rotation, formation of subgrains, and grain growth.

At 300° F the nickel had a high resistance to creep at all stresses up to 45,500 lb/in.² However, with a further increase in stress of only 500 lb/in.² the secondary creep rate increased by a factor of about 100,000. The phenomenon of strain aging was espe-

Effect of temperature on the appearance of nickel fractured in creep studies. All specimens failed at relatively high creep rates. No surface cracking is evident on the specimen fractured at 300° or 700° F. However, numerous cracks may be seen in the surface of the specimen fractured at 900° F. Each specimen exhibits a ductile fracture, a rim effect, and both circumferential and longitudinal flow lines.





Relatively little information has been available on the third stage of creep. The initiation of this stage has been attributed to such factors as the beginning of microcracking, increase in creep stress due to a decrease in the area of the specimen, and atomic rearrangement.

Reference Samples of Isotopic Abundance

MANY LABORATORIES throughout the world are engaged in mass spectrometer research on the natural abundance of isotopes of the various elements. Such research is invaluable in geology and geophysics for determining the age of minerals. It also provides information on the temperature and physical conditions of the earth when various minerals were formed. However, in performing this research each laboratory has adopted arbitrary standards of comparison. Because of this lack of common standards to which all measurements can be referred, an unnecessary uncertainty exists in available isotope abundance data.

For this reason, the Bureau, at the request of the United States Geological Survey, has undertaken a program of preparing and distributing reference samples for use in research on natural abundance of isotopes. Sponsored by the Atomic Energy Commission, the program is being carried out by the Mass Spectrometry Section, under F. L. Mohler.

Samples will be available on an international basis and will consist of elements and compounds in forms suitable for mass spectrometer analysis. As a part of the program, the Bureau is determining the suitability of new chemical compounds for isotope measurements and is developing convenient preparation techniques. The Bureau also will serve as an international clearing

house for data on the natural abundance ratios for these samples. Accumulated data on each element will be distributed with every sample sent out.

It will now be possible, for the first time, for all laboratories doing research on a particular element to be working with the same material. It is expected that use of the bank and compilation of results of different laboratories will tend to minimize the uncertainty in present-day measurements. This will lead to increasingly accurate and reliable values for the isotopic abundances of elements issued as reference samples.

As a preliminary step, a questionnaire was sent to a number of laboratories in the United States and abroad which specialize in isotope abundance research. They were asked to state the elements they were interested in, what chemical form they preferred, and whether they would cooperate in making analyses.

Response to the questionnaire indicated that there is interest in nearly all of the polyisotopic elements, particularly lead and the light elements. There were also requests for standards of deuterium oxide and deuterium. The various laboratories are equipped to make measurements by one or more of three different techniques. Some are prepared to measure gases; others, compounds which are evaporated from a furnace, and others, compounds which are evaporated from a heated

In the NBS experiments, cracks of microscopic dimensions were not found to be a prerequisite for the initiation of the third stage of creep. In all specimens tested at 300°, 700°, and 900° F, internal disintegration was confined to the region of complete fracture, and the fractures were preceded by appreciable necking.

Recrystallization, sometimes accompanied by grain growth, occurred in the specimens fractured in creep at 1,200° F. However, no evidence of recrystallization was detected in a metallographic study of all the specimens fractured in creep at the lower temperatures. The fractures appeared to be predominately transcrystalline at 300°, 700°, or 900° F, and intercrystalline at 1,200° F.

¹ For further technical details, see Creep of high-purity nickel, by William D. Jenkins, Thomas G. Digges, and Carl R. Johnson, *J. Research NBS* **53**, 329 (1954) RP2551.

² For details of the earlier work on high-purity copper, see *NBS Tech. News Bull.* **34**, 130 (Sept. 1950), and **36**, 10 (Jan. 1952). Creep studies of ingot iron and of high-purity aluminum are described in *NBS Tech. News Bull.* **34**, 34 (March 1950) and **34**, 43 (March 1951), respectively.

filament as ions. Lead can be analyzed by all three methods as lead tetramethyl, lead iodide, and lead oxide or sulfide, respectively. The alkali and alkali earth metals are commonly analyzed by thermionic emission.

At the present time 25 different chemical elements are available in 30 different compounds, and the list of elements and compounds is continually increasing. Small samples suitable only for mass spectrometer analyses are sealed in glass tubes for distribution. Gases and volatile liquids are in internal break-seal tubes. Mass spectrometer and spectroscopic analyses confirm that the materials are of suitable purity for the purpose. Solid samples are carefully ground and mixed to assure homogeneity.

Most of the reference samples have been obtained from commercial sources, but in a few instances the Geological Survey has supplied natural minerals. The lead is from galena mined in Ivigtut, Greenland, the limestone is from a quarry in Bavaria, and the sulfur is from a sulfur dome in Texas. The sulfur reference

samples are supplied both as native sulfur and as SO_2 , and samples of the air used to make the SO_2 are available. This is desirable because isotopes of the SO_2 ion are commonly measured, and oxygen as well as sulfur contribute to the isotope pattern.

Other samples include water, hydrogen made from this water, deuterium oxide (heavy water) and deuterium gas derived from it, rare gases, alkali and alkali earth carbonates or salts, boron trifluoride, silicon tetrafluoride, compounds of copper, silver, and cadmium. There is also a small amount of pure mercury which was prepared as a density standard by the National Physical Laboratory in England.

Samples are now being distributed to various laboratories that have offered to collaborate in the analyses. Results of these analyses will be compiled and distributed to all laboratories that use the samples. Subsequently the samples will be sold for a nominal fee, and all users will be asked to report their measurements to the Bureau laboratory.

Asphalt Durability Test Method

ACCCELERATED test methods for determining the weathering resistance of asphalt have been evaluated at the Bureau in connection with studies of the mechanism of degradation of asphalt on weathering. Various combinations of light, water, and thermal shock were investigated for their effects on three coating grade asphalts. The combination selected as a result of this evaluation was one that produced sufficiently rapid failure of the asphalts with good differentiation among their durabilities. The study was conducted by L. R. Kleinschmidt of the NBS staff and by S. H. Greenfeld of the Asphalt Roofing Industry Bureau's research fellowship at the Bureau.

Asphalts, widely used in roofing, are relatively inert organic materials that degrade very slowly when exposed to the weather. Because there are wide differences in their durability, a rapid method of distinguishing among them has long been sought, and for a number of years various accelerated durability tests have been in use. Numerous combinations of light, water, heat, and thermal shock—the principal factors involved in the degradation of asphalts—have been proposed and used, but the most effective combination or sequence of these factors has been uncertain.

In this study the asphalt specimens were mounted in each of four accelerated durability machines. These machines were simply drums in which specimens were exposed to controlled sources of light, heat, and water. The specimens were mounted on the inside walls of drums 30 in. in diameter, which rotated at 1 rpm around a central light source. A satisfactory light source for accelerated exposure tests was a low-intensity enclosed carbon arc operating in the range of 130 to 145 volts and 15 to 17 amperes. Because this source is almost universally used for asphalt testing, it was chosen as the light source in this investigation.

The water used for the spray was demineralized to a salt content of less than 2 parts per million and a pH of 6 to 6.2, and was delivered to the spray nozzles in the accelerated durability machines at about 25 psi. In some of the exposures the water was chilled to 40° F while in others it was at 77° F, the temperature of the room. Some of the specimens were periodically refrigerated at -5° F.

The test specimens were prepared from three coating grade asphalts (I, II, III) from widely different sources. Although the three asphalts are not normally exposed to the same climatic conditions in service, experience indicates that asphalt II should be the most durable and asphalt I, the least. Each asphalt was poured onto aluminum panels and spread to uniform thickness (0.025 ± 0.0015 in.) in a hydraulic press.¹ All coatings were nominally $2\frac{3}{4}$ by $5\frac{1}{4}$ in. in area. They were exposed within 24 hr of preparation. During exposure the specimens were mounted on aluminum supports with stainless steel clips, two specimens to a support, one above the other. These supports fitted tightly into the regular panel-holding slots in the drums of the accelerated durability machines. To equalize the effects of the vertical gradients of heat, light, and water, the panels and supports were inverted on alternate days. At regular intervals, the coatings were inspected by means of a high voltage probe, and spark photographs^{2,3} were taken of all coatings containing breaks through to the base aluminum. These photographs were evaluated through a grid of 60 rectangles. When breaks in the coating showed in 30 or more of the rectangles, the panel was removed, and this was considered the end-point of the test for that particular specimen.

Duplicate specimens of each of the three asphalts



Roofing asphalt samples of weathered material are periodically inspected for cracks by spark photography. A piece of photographic paper is placed over the specimen, and the sparks passing through the breaks in the asphalt expose the paper.

were exposed to six different combinations¹ of light, water, refrigeration, and rest which follow:

Cycle 1. Twenty-one-hour exposure to light only, followed by one-hour spray washing (temperature of spray water 77° F) and a 2-hour rest at ambient conditions.

Cycle 2. Twenty-one-hour exposure to light only, followed by one-hour refrigeration at -5° F and a 2-hour rest period at ambient conditions.

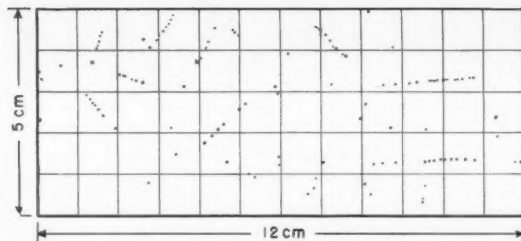
Cycle 3. Twenty-one-hour exposure to light only, followed by one-hour refrigeration at -5° F, one hour of water spray (temperature of spray water 77° F) without light and a one-hour rest period at ambient conditions.

Cycle 4. Fifty-one-minute exposure to light only, followed by 9-minute exposure to light and water spray (temperature of water 77° F). These operations were repeated for 21 hours, the specimens were then held at ambient conditions for 3 hours.

Cycle 5. Same as cycle 4 except 40° F spray water was used.

Cycle 6. Seventeen-minute exposure to light only, followed by 3-minute exposure to light and water (temperature of spray water 77° F). These operations were repeated for 21 hours, the specimens were then held at ambient conditions for 3 hours.

Results of this investigation reveal that the times to failure were largely in the reverse order of the severity of the thermal shock. In each cycle the duplicate specimens of asphalts I and II failed simultaneously except in two instances when they were within one inspection period (about 7 days) of each other, but in cycles 4 and 5 the duplicate specimens of asphalt III failed three inspection periods apart. Asphalts I, II, and III



Cracks in asphalt specimen appear in lines of dots as recorded by spark photography. A grid of 60 rectangles (5 by 12 cm) is then laid over this record. If breaks show through more than 30 of the rectangles, specimen is removed from the test.

all failed after 44 days exposure to cycle 2 and 42, 56, and 47 days in cycle 3. Cycles 2 and 3 were considered the most severe of any cycles used.

Cycle 1, considered the least severe, required exposures of 116, 227, and 127 days to effect failure in asphalts I, II, and III, respectively. Cycles 1, 2, and 3 contained no water spray during the light exposure. In cycles 4, 5, and 6, the water spray during light exposure introduced a thermal shock. This shock, although not as severe as the shock from the refrigeration period in cycles 2 and 3, also lessened the times to final failure.

Of the six combinations of light, water, and thermal shock, cycle 5 appeared to be the most satisfactory since it differentiated well among the durabilities in times that were not considered excessive. Therefore, the cycle was proposed to Subcommittee VIII of Committee D-8 of the American Society for Testing Materials as one of the standard test cycles in a new, revised version of D539, "Tentative Recommended Practice for Accelerated Weathering Test of Bituminous Materials."²

TABLE 1. Durability data for the three asphalts exposed to six different weathering cycles

Cycle *	Asphalt		
	I	II	III
1	Days 116	Days 227	Days 127
2	44	44	44
3	42	56	47
4	61	105	82
5	40	66	57
6	48	66	70

* Test conditions for the various cycles: (1) 21 hr light, 1 hr water spray and 2 hr rest; (2) 21 hr light, 1 hr refrigeration at -5° F and 2 hr rest; (3) 21 hr light, 1 hr refrigeration at -5° F, 1 hr water spray, and 1 hr rest; (4) 51 min light, 9 min light and 77° F water spray, operations repeated for 21 hr, then 3 hr rest; (5) 51 min light, 9 min light and 40° F water spray, operations repeated for 21 hr, then 3 hr rest; (6) 17 min light, 3 min light and 77° F water spray, operations repeated for 21 hr, then 3 hr rest.

¹ A method for preparing uniform films of bituminous materials, by S. H. Greenfield, *ASTM Bulletin No. 193 (Oct. 1953)*.

² The design and application of a spark-gap instrument for detecting crack failures of asphalt coatings during weathering tests, by A. H. Boenau and L. H. Baum, *Special Technical Publication No. 94 ASTM (1949)*.

²A new method for evaluating failure of bituminous materials due to weathering, by J. B. Hunter, F. C. Gzenski, and L. Laskaris, *Special Technical Publication No. 94, ASTM* (1949).

⁴The combinations of light, water, refrigeration, and

rest are referred to as cycles.

⁵Influence of exposure conditions on the accelerated durability test of asphalts, by L. R. Kleinschmidt and S. H. Janfeld, *ASTM Bulletin* (issue not announced yet).

Rapid Determination of Strontium and Manganese in Cement

THE BUREAU has developed methods for the flame-photometric determination of strontium and manganese in cements. J. J. Diamond of the concreting materials laboratory has shown that SrO ¹ and Mn_2O_3 ² contents may be rapidly and accurately determined on the same cement sample used to determine the alkalies.

These methods were developed as part of a continuing NBS program to apply modern instrumental techniques to the determination of the minor constituents of cement, that is, those present in amounts less than 1 percent. During the course of this program, methods have also been worked out for determining titania,³ sodium,^{4,5} and potassium⁴ in cements.

It is customary to assume that cement contains some strontium. However, little or no information on the subject has been available because the applicable methods for the determination of strontium in the presence of a thousand times as much calcium were difficult and unreliable. The flame photometer was selected as the research instrument in this work since it had been used to determine strontium content in other substances and was established as a standard instrument for the determination of the alkalies in cement. While the determination of manganese in cement has not been as difficult, since the volumetric "permanganate" and "bismuthate" methods are available, it seemed desirable to use the more rapid and equally accurate flame photometry for manganese too, if possible. One advantage of the flame-photometric method is that it does not require previous chemical separation of the substance to be studied. All determinations can be made on the same 1-g sample of cement, dissolved in hydrochloric acid and filtered to remove any insoluble material.

The cements were studied on a standard spectrophotometer with a flame photometer attachment, an oxyhydrogen burner, and a photomultiplier attachment. Experiments with pure solutions indicate that peaks in the emission of strontium occur at about 461 and 675 $\text{m}\mu$. However, since the instrument is more sensitive at 461 $\text{m}\mu$, and since there is less interference from calcium at that wavelength, 461 $\text{m}\mu$ was selected for the determinations.

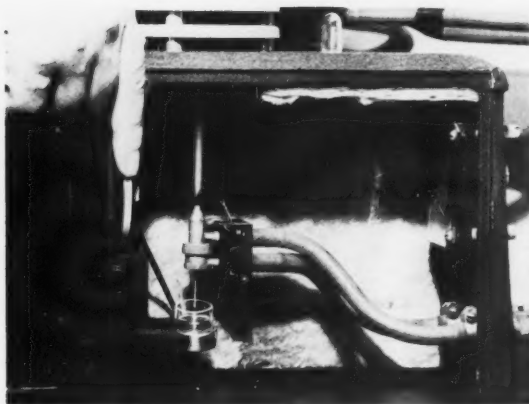
In the analytical procedure adopted, a 1-g sample of cement is dissolved in hydrochloric acid, filtered,

and diluted to 100 ml. This solution is then compared with a series of solutions made up from a low-strontium cement of previously determined strontium content. The solutions are prepared by adding standard-strontium solution to five 1-g samples of the standard cement so as to give standards containing 10, 20, 30, 40, and 100 ppm strontium oxide. These amounts correspond to 0.1, 0.2, 0.3, 0.4, and 1.0 percent strontium oxide in cement, respectively. The comparisons are made by atomizing the 100-ppm standard into the oxyhydrogen flame and balancing the meter at the 461- $\text{m}\mu$ wavelength. The cement solution is then atomized, the meter again balanced by means of the "%T" control and the "%T" recorded. (For this application, the "%T" is a measure of the relative intensity of the flame.) The process is repeated for the other reference standards and the cements under test. The amount of strontium in the cement tested can then be determined graphically or by interpolation using the data obtained from the reference solutions. An appropriate correction is made for background radiation.

In very-low-strontium cements—less than 0.05 percent strontium oxide—the strontium content may also be determined by the method of "standard addition". In this method, two 1-g samples of cement are dissolved



Solutions of cements are placed in the small beakers and atomized into the flame for photometric analysis. Their sodium, potassium, strontium, and manganese contents are then determined by comparison of the emitted radiation with that of appropriate standards. The instrument is a standard spectrophotometer with a flame photometer and the photomultiplier attached.



Burner-atomizer system of the flame-photometer. Cement solution is positioned below the burner by means of a milled dial to avoid contact with very hot oxyhydrogen flame. Solution is atomized into the flame by capillary action through a small palladium tube. Mirror (right) redirects light to the mirror-and-prism system of instrument.

in hydrochloric acid and the insoluble material filtered out. Five ppm of strontium oxide is added to one of the samples before final dilution, and the strontium emissions of the two specimens are compared. The strontium originally present is then calculated by simple proportion on the assumption that the calibration curve is linear for low strontium concentrations.

The Bureau has used the flame-photometric method to obtain data on over 100 cement samples from 30 states and two foreign countries. The strontium content ranged from 0.02 to 0.39 percent—0.14 percent being the average. All 17 of the cements having 0.29 percent strontium oxide or more originated in the heart of the Lehigh Valley in Pennsylvania. In general, it was found that cements originating in the same geographical region tend to have similar strontium contents.

The flame-photometric methods developed by the Bureau have been used not only for original research but to confirm or revise data gathered by other experimental methods. For example, strontium was redetermined in NBS Standard Sample 1A, argillaceous limestone, by the flame-photometric method. It was found to have a larger SrO content than that certified many years ago when less refined techniques were available for this analysis. The strontium content of NBS Standard Sample 88, dolomite, has also been redetermined and has been found in agreement with the certificate value of "less than 0.01 percent SrO". A cement with a known low strontium content (0.05 percent) has recently been made available as an NBS standard sample to serve as a reference cement.⁶

The manganese content of cement can be determined by the flame photometer at the same time as strontium and on the same 1-g sample, by comparison with a series of standards made up from a low-manganese cement. The procedure is essentially the same as that used for strontium, with the manganese determinations being made at the wavelength 403.4 mμ. It was found that the method works equally well whether applied to portland cements, which are usually fairly low in

manganese, or to the high-manganese blast-furnace slag cements. The Bureau has used this method to determine manganese in two portland cements and in one portland slag cement. These cements were also analyzed colorimetrically as a check on the flame photometric method. Results (table 1) indicate the precision and accuracy are quite satisfactory.

The flame-photometric method has already been established as a reliable test for sodium and potassium. Since strontium and manganese can now be determined on the same 1-g sample, the flame-photometric method may become a standard substitute method for determining these elements. Not only is the method fast and accurate, but the analysis can be carried out by most operators with only a moderate amount of instruction.

¹ For further technical details, see Flame photometric determination of strontium in portland cement, by J. J. Diamond, *Anal. Chem.* **27**, 913 (June 1955).

² For further technical details, see The Flame photometric determination of manganese in cement, by J. J. Diamond, *Anal. Chem.* (in press).

³ Spectroscopic determination of titania in portland cement, by J. J. Diamond, *Rock Products* **49**, 103 (4-16).

⁴ Studies on the flame photometer for the determination of Na₂O and K₂O in portland cement, by W. R. Eubank and R. H. Bogue, *J. Research NBS* **43**, 173 (1949) RP2019.

⁵ Improvements in flame photometric determination of sodium in portland cement, by J. J. Diamond and Leonard Bean, *Anal. Chem.* **25**, 1825 (1953).

⁶ Standard Sample 177, Portland Cement (issued September, 1955).

TABLE 1. Mn₂O₃ content of cement

Sample	Colorimetric method	Flame photometric method	
		Sample 1 ^a	Sample 2 ^a
Portland cement A.....	0.049	0.048	0.050
Portland cement B.....	.26	.25	.25
Portland blast furnace slag cement.....	.60	.58	.60
White portland cement.....	.013	Reference standard	

^a Two samples of each specimen were analyzed on successive days.

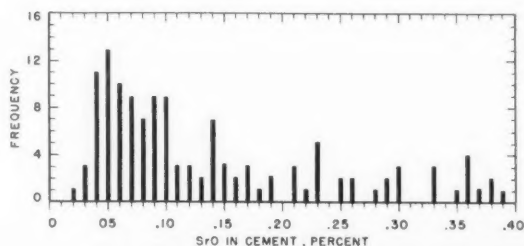


Diagram showing the SrO content of 128 cements analyzed by flame-photometry. More than half of the cements analyzed contain less than 0.10 percent of strontium oxide.

Rapid Determination of Lens Distortion

A STUDY by the Bureau has shown that the distortion in the image produced by a projection lens can be readily calculated as a linear function of the magnification. A. A. Magill of the Bureau's optical instruments laboratory has developed a simple equation which expresses the distortion at any magnification in terms of the magnification and of two previously measured distortions.¹ This equation should be particularly valuable in the field of photogrammetry, where high precision is required in order to produce accurate maps from aerial photographs.

The distortion produced by a lens when used for copying or projection varies with the magnification at which it is used. It has been customary, when high precision work is involved, to measure distortion in the laboratory for each object-to-image ratio employed. However, when the equation developed at NBS is used, distortion need be measured at only two magnifications.

The two distortions used are those obtained with parallel light incident, in turn, on the front and on the back of the lens. These distortion values not only require the simplest experimental setup but also have special significance in being determined at the limits of real image formation.

Specifically, if D_0 represents the distortion obtained with parallel light incident on one side of the lens (zero magnification), D_{00} the distortion obtained with parallel light incident on the other, and m any finite magnification, then the distortion D_m at any finite magnification is given by $D_m = D_0 - mD_{00}$.

The definition of distortion used for the Bureau's equation is simply the lateral displacement of the image from its theoretical distortion-free position. A relation between distortion and magnification previously developed by E. Wandersleb² is hyperbolic since he defines distortion as the ratio of the displacement of the image to the distance between the distortion-free position and the axis of the lens.

The Bureau has verified the linear equation for three commonly used types of symmetrical objectives at relative apertures of $f/22$. It was concluded that under certain limitations the same type of computation may be carried out with other kinds of lenses.

¹ For further technical details, see Variation in distortion with magnification, by A. A. Magill, *J. Research NBS* 54, 135 (1955) RP2574.

² E. Wandersleb, Über die Verzeichnungs Fehler Photographischer Objectiv, *Z. Instrumentenk.* 27, 33-37, 75-85 (1907). The equation is also used in many optical texts.

Preparing Thin Asphalt Films by Spinning

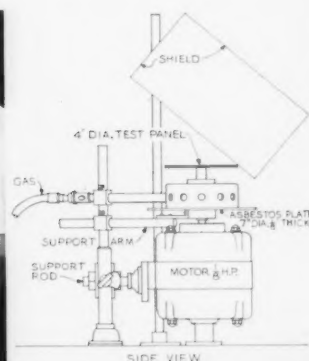
A RAPID METHOD for preparing thin asphalt films¹ in the image produced by a projection National Bureau of Standards in connection with a study of asphalt weathering properties. By this method, thin films are readily obtained by pouring molten asphalt on a rapidly spinning disk; the variables in the procedure can be controlled to produce film thicknesses from 0.0005 to 0.050 in. The procedure was developed by L. R. Kleinschmidt of the Bureau's floor, roof, and wall coverings laboratory.

In the study of asphalt degradation, many replicate test specimens are usually prepared for exposure either to outside weathering conditions or to light, heat, and water in accelerated exposure test machines. In some of the tests at NBS where specific coating thicknesses greater than 0.015 in. are required, the specimens are prepared by either the doctor blade or the hydraulic press method. However, these methods are satisfactory only when coatings thicker than 0.015 in. are desired.

In the rapid method for preparing thin asphalt films for test specimens the operator pours molten asphalt onto a rapidly spinning disk (hidden inside protective shield). Variables in the process can be controlled to produce any film thickness from 0.0005 to 0.050 in. Right: Plan shows placement of equipment. Ring burner preheats panel to its working temperature; the heat insures good bonding between the panel and the asphalt. An asbestos plate under the burner prevents asphalt from dripping on motor. A shield (shown raised) retains material thrown from the disk during coating.

In an effort to prepare thinner films, another method was sought, and the one originally developed for paint and varnish films by pouring such materials onto a spinning disk² was examined. This process was adapted to the Bureau's needs by providing a means for preheating the aluminum test panel to insure good bonding, and by heating the asphalt to an appropriate pouring consistency. The spinning-disk method is also applicable to other materials that have narrow softening-point ranges, rather than definite melting points, such as paraffin or stearic acid rosin.

The equipment consists simply of a 1/4-hp shunt-wound d-c motor, mounted on end, with a shaft exten-



F	Page
Flame spread, radiant panel test for (Oct.)	142
Fibrous materials, brown-line effect on (June)	87
Fire tests of brick walls (<i>publication announcement</i>) (Feb.)	23
Frequency standard, portable secondary (July)	92
Frost closure of roof vents in plumbing systems (Mar.)	34
G	
Gage blocks, symposium on precision (Nov.)	157
Gamma rays at oblique incidence, attenuation of (Feb.)	17
Gas diode, the cold-cathode (May)	61
Gas diode voltage characteristics, improving (May)	64
Glass-fiber paper, improved (June)	82
Graphites, oxidation studies of natural (June)	85
Gravity warm-air heating of basementless houses (July)	98
H	
Heating of basementless houses, gravity warm-air (July)	98
High-density tape recording for digital computers (Sept.)	121
High-pressure equipment, insulating seal for (May)	71
Hot-wire anemometer in supersonic flow (Mar.)	38
Hydraulic cements, cracking resistance of (Sept.)	128
I	
Illumination, Thirteenth Session of the International Commission on (Oct.)	147
Improved glass-fiber paper (June)	82
Improved method for applying cements (Aug.)	112
Improved techniques for impregnating leather (July)	96
Improving gas diode voltage characteristics (May)	64
Instruments reference service (Aug.)	110
Insulating seal for high-pressure equipment (May)	71
Interference fringes, photoelectric counters for (Oct.)	144
International comparison of radium standards (Apr.)	45
International Geophysical Year (Oct.)	164
J	
Jet-engine alloys, analysis of (Oct.)	146
Jerkmeter, a cardiographic (Dec.)	161
L	
Laboratory evaluation of sounding balloons (July)	101
Large vibration machine (Feb.)	24
Leather, improved techniques for impregnating (July)	96
Leather, micropores in (May)	68
Lens distortion, rapid determination of (Dec.)	169
Light, velocity redetermined (Jan.)	1
Linear equations, solution of (Feb.)	30
Linear programming symposium (Apr.)	50
Low-expansion cobalt-iron-chromium alloys (Nov.)	156
M	
Magnesium alloys, electrolytically formed coating for (June)	77
Magnetic tape and wire, a rotating reading head for (Aug.)	116
Masonry, building code requirements for (<i>publication announcement</i>) (Apr.)	51
Measurement of carbon-14 in solution (Feb.)	25
Measurements, experimental designs for duplicate (July)	90
Melting apparatus, zone (June)	81
Micropores in leather (May)	68
Motion picture film announcements:	
Dental bars in action (Feb.)	31
Dental materials: specification and certification (Aug.)	119
True standard (Feb.)	31
Mutual inductance transducers, design criteria for (Mar.)	36
N	
Nature of stark rubber (Aug.)	117
NBS-BuAer preferred circuits program (Oct.)	134
NBS Open House (Apr.)	52
New radiochemistry laboratory (Sept.)	126
Nickel, creep of high-purity (Dec.)	162
Noise, test for instrument cable (Nov.)	151
O	
Open House, NBS (Apr.)	52
Organic coating, abrasive jet method for (Mar.)	33
Oscillator, subharmonic crystal (Feb.)	19
Oxidation studies of natural graphites (June)	85
Ozone detector, automatic photoelectric (Feb.)	28

P	Page
Paper, improved glass-fiber (June)	82
pH determinations, electrometric (Feb.)	30
Photoelectric counters for interference fringes (Oct.)	144
Photoelectric automatic ozone detector (Feb.)	28
Photoneutron national standard, absolute calibration of (Oct.)	110
Pipe, effect of soils on asbestos-cement (Feb.)	26
Plumbing system roof vents, frost closure of (Mar.)	34
Portable secondary frequency standard (July)	92
Portable standard cell comparator (Aug.)	114
Postdoctoral Research Associateships granted by NBS (Sept.)	130
Potting machine, automatic (June)	79
Preparing thin asphalt fibers by spinning (Dec.)	169
Pyrotechnic smokes, colorimeter for (July)	95
R	
Radiant panel test for flame spread (Oct.)	142
Radiation balance (Jan.)	6
Radiochemistry laboratory, new (Sept.)	121
Radium standards, international comparison of (Apr.)	45
Rapid analysis of rubber vulcanizates (Nov.)	153
Rapid determination of lens distortion (Dec.)	169
Rapid determination of strontium and manganese in cement (Dec.)	167
Recent advances in electronic process technology (Jan.)	8
Reference samples of isotopic abundance (Dec.)	116
Reference service, instruments (Aug.)	110
Regulators, electronic voltage (Aug.)	108
Reinforced concrete, control of cracks in (Sept.)	129
Rheology Society meets at NBS (Jan.)	15
Roofing asphalt, chromatographic fractionation of (Apr.)	49
Roof vents in plumbing systems, frost closure of (Mar.)	34
Rotating reading head for magnetic tape and wire (Aug.)	116
S	
Selection of bolt materials for underground service (May)	73
Semimicro dilution viscometer (Nov.)	158
Sines and cosines for radian arguments, tables of (<i>publication announcement</i>) (Sept.)	125
Sixth National Conference on Standards (Oct.)	133
Smokes pyrotechnic, colorimeter for (July)	95
Society of Rheology meets at NBS (Jan.)	15
Solution of linear equations (Feb.)	30
Sound transmission loss, continuous recording of (Sept.)	121
Spectacle tester (Oct.)	137
Spectrographic standard samples of tool steels (Aug.)	105
Standards, Sixth National Conference on (Oct.)	133
Stark rubber, nature of (Aug.)	117
Study of cellular concretes (Mar.)	41
Subharmonic crystal oscillator (Feb.)	19
Symposium of precision gage blocks (Nov.)	157
T	
Tables of sines and cosines for radian arguments (<i>publication announcement</i>) (Sept.)	125
Tape and wire, rotating reading head for magnetic (Aug.)	116
Temperature Symposium, Third (Feb.)	22
Tenth International Conference on Weights and Measures (Jan.)	13
Test for instrument cable noise (Nov.)	151
Testing laboratories, ASTM issued directory of (Apr.)	59
Third Temperature Symposium (Feb.)	22
Thirteenth Session of the International Commission on Illumination (Oct.)	147
Tool steel samples, spectrographic standards of (Aug.)	105
Transducers, ceramics for piezoelectric (Nov.)	149
Transducers, design criteria for mutual inductance (Mar.)	36
True standard (<i>motion picture announcement</i>) (Feb.)	31
V	
Velocimeter, an automatic underwater (July)	89
Velocity of light redetermined (Jan.)	1
Vibration machine, a large (Feb.)	24
Viscometer, semimicro dilution (Nov.)	158
Vulcanizates, rapid analysis of rubber (Nov.)	153
W	
Walls, fire tests of brick (<i>publication announcement</i>) (Feb.)	23
Weights and Measures Conference (July)	94
Weights and Measures, Tenth International Conference on (Jan.)	13
Wire, rotating reading head for magnetic tape and (Aug.)	116
Z	
Zone melting apparatus (June)	81

Publications of the National Bureau of Standards

Journal of Research of the National Bureau of Standards, volume 55, No. 5, November 1955 (RP2626 to RP2632 incl.). Annual subscription \$4.00.

Technical News Bulletin, volume 39, No. 11, November 1955. 10 cents. Annual subscription \$1.00.

Basic Radio Propagation Predictions for February 1955. Three months in advance. CRPL-D 134. Issued November 1955. 10 cents. Annual subscription \$1.00.

Research Papers

Journal of Research, volume 55, number 5, November 1955. Single copies of the Journal vary in price. Single copies of Research Papers appearing in the Journal are not available for sale. The Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., will reprint 100 or more copies of a Research Paper. Request for the purchase price should be mailed promptly to that office.

UNITED STATES
GOVERNMENT PRINTING OFFICE

DIVISION OF PUBLIC DOCUMENTS
WASHINGTON 25 D. C.

OFFICIAL BUSINESS

PENALTY FOR PRIVATE USE TO AVOID
PAYMENT OF POSTAGE, \$300
(GPO)



TECHNICAL
NEWS
BULLETIN

U. S. DEPARTMENT OF COMMERCE
SINCLAIR WEEKS, Secretary
NATIONAL BUREAU OF STANDARDS
A. V. ASTIN, Director

December 1955 Issued Monthly Vol. 39, No. 12

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Subscription price, domestic, \$1.00 a year; 35 cents additional for foreign mailing; single copy, 10 cents. The printing of this publication has been approved by the Director of the Bureau of the Budget, March 6, 1953.

Contents

	Page
A cardiographic jerkmeter.....	161
Creep of high-purity nickel.....	162
Reference samples of isotopic abundance.....	164
Asphalt durability test method.....	165
Rapid determination of strontium and manganese in cement.....	167
Rapid determination of lens distortion.....	169
Preparing thin asphalt films by spinning.....	169
Index, volume 39, 1955.....	170
Publications of the National Bureau of Standards.....	171

NBS Publications (continued)

- RP2626. Properties of piezoelectric ceramics in the solid-solution series lead titanate-lead zirconate-lead oxide: tin oxide and lead titanate-lead hafnate. B. Jaffe, R. S. Roth, and S. Marzullo.
- RP2627. Heat capacity, heats of fusion and vaporization, and vapor pressure of decaborane ($B_{10}H_{12}$). George T. Furukawa and Rita P. Park.
- RP2628. Preparation of titanium tetrachloride of high purity. W. Stanley Clabaugh, Robert T. Leslie, and Raleigh Gilchrist.
- RP2629. Liquid-vapor phase equilibrium in solutions of oxygen and nitrogen at pressures below one atmosphere. George T. Armstrong, Jack M. Goldstein, and D. Ellis Roberts.
- RP2630. Precise measurement of wavelengths in infrared spectra. Earle K. Plyler, Lamdin R. Blaine, and Eugene D. Tidwell.
- RP2631. Ideal gas thermodynamic functions of the isotopic hydrogen sulfides. Lester Haar, Joe C. Bradley, and Abraham S. Friedman.
- RP2632. Measurement of field distortion in free-air ionization chambers by analog method. William Miller and Robert J. Kennedy.

Miscellaneous Publications

- M216. Report of the 40th National Conference on Weights and Measures. 70 cents.

Publications in Other Journals

- Absorption by concrete of X-rays and gamma-rays. B. E. Foster. BuDocks Technical Digest No. 56, May 1955.
- Paper milk containers. M. W. Jensen. Scale Journal (176 W. Adams St., Chicago 3, Ill.) 41, No. 12, 5 (Sept. 1955).
- Distribution of electrons scattered by gold. L. Marton, J. Arol Simpson, and T. F. McCraw. Phys. Rev. (57 E. 55th St., New York 22, N. Y.) 99, No. 2, 495 (July 1955).
- Physiological monitor for anesthesia. S. R. Gilford and H. P. Broida. Electronics (330 W. 42d St., New York 36, N. Y.) 28, No. 10, 130 (Oct. 1955).
- Crazing of acrylic resins. W. T. Sweeney, G. M. Brauer, and I. C. Schoonover. J. Dental Research (International Assoc. for Dental Res., C. V. Mosby Co., St. Louis 3, Mo.) 34, No. 3, 306 (June 1955).

- Atomic flames: spectra, "temperatures," and products. R. E. Ferguson and H. P. Broida. Fifth Symposium (International) on Combustion published by Reinhold Publishing Corp. (430 Park Ave., New York 22, N. Y.) 754 (1955).
- Information theory aspects of propagation through time-varying media. Joseph Feinstein. J. Appl. Phys. (57 E. 55th St., New York 22, N. Y.) 26, No. 2, 219 (Feb. 1955).
- Nonlinear theory of space-charge wave in moving, interacting electron beams with application to solar radio noise. Hari K. Sen. Phys. Rev. (57 E. 55th St., New York 22, N. Y.) 97, No. 4, 849 (Feb. 1955).
- Temperature control during mixing of rubber compounds. Frank L. Roth, George E. Decker, and Robert D. Stiehler. Rubber World (386 4th Ave., New York 16, N. Y.) 132, 482 (July 1955).

Publications for which a price is indicated are available only from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (foreign postage, one-third additional). Reprints from outside journals are not available from the National Bureau of Standards but can often be obtained from the publishers.

Patents

- (The following U. S. Patents have been granted to NBS inventors. Assignor to the United States of America as represented by the Secretary of the Department noted in brackets.)
- No. 2,713,927. July 26, 1955. Magnetic fluid clutch shaft seal. Jacob Rabinow. (Navy).
- No. 2,714,928. August 9, 1955. Selectively operated punches mounted in an airtight compartment. Israel Rotkin, Jacob Rabinow, and Joseph A. Guaracini. (Commerce).
- No. 2,715,058. August 9, 1955. Preparation of lower chlorides of molybdenum and tungsten. Seymour Senderoff and Roger J. Labrie. (Commerce).
- No. 2,715,093. August 9, 1955. Electrolytic production of molybdenum powder and coherent deposits. Seymour Senderoff and Abner Brenner. (Commerce).
- No. 2,715,617. August 16, 1955. Bearing compositions containing polytetrafluoroethylene. Hobart S. White. (Navy).
- No. 2,717,981. September 13, 1955. Magnetostriction traveling-wave transducers. Maurice Apstein. (Commerce).

